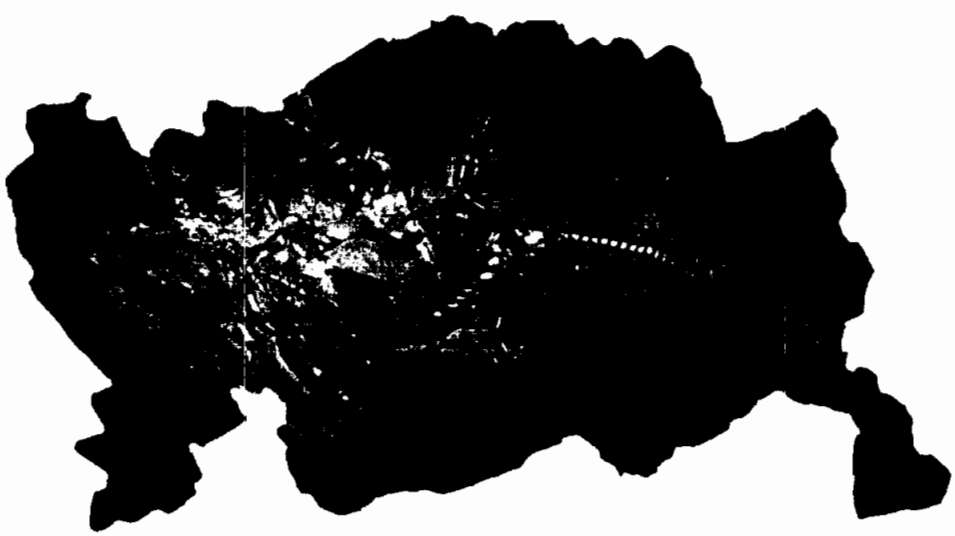
# NOMINATION

of

# MONTE SAN GIORGIO

for

## INCLUSION on the WORLD HERITAGE LIST



# 2. Justification for Inscription

## a. Statement of significance

Monte San Giorgio is one of the most important fossil-bearing areas in the world, particularly as regards its palaeontological heritage from the Middle Triassic Period (approximately 245 to 230 million years ago). The outstanding value of the fossils contained in the Middle Triassic carbonate formations of this mountain is determined by the following factors:

- ***Palaeontological diversity**:* scientific excavations have brought to light **more than 10,000 fossil specimens** (Fig. 11), mostly complete, including the fossils of:
  - approximately **thirty species of marine and land-based reptiles**,
  - approximately **eighty different species of fish**,
  - **hundreds of species of invertebrates** (bivalves, ammonites, echinoderms, crustaceans, insects, etc.), and
  - **many plant species**.

A large proportion of the fossils are perfectly preserved, many are large in size (up to 7 metres long) and, because they are of considerable aesthetic value, are displayed, mainly in the form of casts, in museums all round the world.

- ***Rare and even unique specimens:*** many vertebrate and invertebrate fossils have been found for the first time and/or exclusively in the rocks of Monte San Giorgio. They are therefore **unique discoveries**. The attribution of scientific names based on toponyms in the Monte San Giorgio area confirms this fact. Examples are: *Ceresiosaurus*, *Serpianosaurus, Ticinosuchus*, *Meridensia meridensis*, *Ticinepo mis*, *Neusticosaurus serpianensis, Luganoia, Tintorina meridensis, Sangiorgio saurus,* etc.
- ***An abundance of "fauna":*** one of the most significant aspects of Monte San Giorgio's palaeontological heritage is undoubtedly the presence of a **continuous sedimentary succession** in the Middle Triassic documenting a geological history of about 15 million years. Unlike other palaeontological deposits of international importance – which usually have just one fossil level attributable to a particular moment in geological history – **Monte San Giorgio has at least five quite distinct, superimposed fossil levels.** This makes it possible to carry out evolutionary studies, over several million years, of particular groups of organisms in the same environment (Fig. 10). Marine reptiles, fish and some invertebrates

(e.g. ammonites and the bivalve *Daonella*) have been the subject of specific studies in this field.

- ***Geology:*** the Middle Triassic fossil-bearing formations of Monte San Giorgio are **a key component in the longer geological history of the Southern Alpine Series (Sudalpino)** (Fig. 7), comprising rocks which extend from approximately 350 million years ago to the present day. The best-known localities, situated in a very restricted area around Monte San Giorgio, or on the mountain itself, include:
  - the Carboniferous formations of Manno,
  - the Permian formations of Arosio-Mugena and the base of Monte San Giorgio itself,
  - the other Lower, Middle and Upper Triassic formations in the Lugano area and on Monte San Giorgio itself,
  - the Jurassic series of the Tremona-Arzo-Besazio-Rancate area, which all falls within the buffer zone around the fossil-bearing levels (Fig. 4) of Monte San Giorgio,
  - the contemporaneous formations of Monte Generoso and the Gole della Breggia (Castel San Pietro, Balerna, Morbio superiore and Morbio inferiore),
  - the latter locality also includes Cretaceous and Tertiary rocks,
  - the Pliocene formations of Castel di Sotto (Novazzano),
  - recent glacial and fluvial deposits of the Quaternary period.

These unusual features of Monte San Giorgio, complementing as they do the Middle Triassic fossil-bearing deposits, are a **significant bonus** from both a scientific and an educational point of view. This is reflected in the proposal that a buffer zone will be established around the protection area in order to set the Middle Triassic features in a broader geological environment.

- ***State of conservation of the fossils:*** as a result of the fossilisation processes involved, the palaeontological specimens are **exceptionally well preserved**, especially in terms of the completeness of the skeletons and fossil remains generally, and of the details of their morphological characteristics.
- ***Protection of the deposits in the past:*** Unlike other fossil-bearing sites, palaeontological research on Monte San Giorgio has always been the exclusive preserve of the Palaeontological Institute and Museum of the University of Zurich, the Department of Earth Sciences of the University of Milan, and the Milan Museum of Natural History. For this reason, the scientific world is in possession of

**a complete, well-preserved, catalogued and studied palaeontological heritage**, not scattered among private collections.

- ***Scientific studies:*** Monte San Giorgio is **one of the most thoroughly studied palaeontological sites in the world**. Over the last 150 years, it has been the subject of some 800 scientific and more popular publications on palaeontological, geological and geomineral topics (see Appendix **A**), including no less than **360 scientific books and papers devoted to its fossil heritage**. As well as these, there have been many texts of a more popular character, about the history of mining activity and quarrying.

- ***Relationship between human settlement and territory:*** the fossil-bearing formations of Monte San Giorgio have **close links with the life of the local people**:

  - in the past, the bituminous shales of the area were mined for the extraction of Ichthyol; there was also quarrying (for the production of gypsum peat and lime) and cutting of ornamental stone (Arzo "marble", Broccatello, etc.);
  - nowadays, the local population is fully involved in the preservation and management of its palaeontological heritage (Meride Fossil Museum, other fossil museums on the Italian side, publications, ad hoc municipal committees, work groups, etc.).

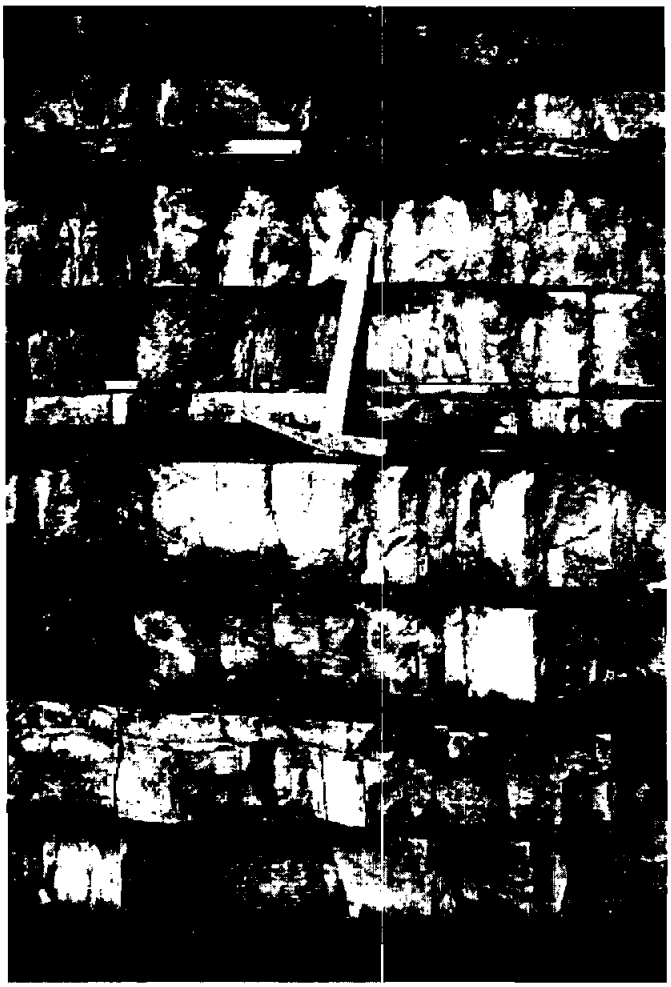


*Fig. 5: Layers of dolomite alternating with bands of bituminous shale (Point 902, Monte San Giorgio) (Photograph: Pal. Inst. Univ. Zurich)*

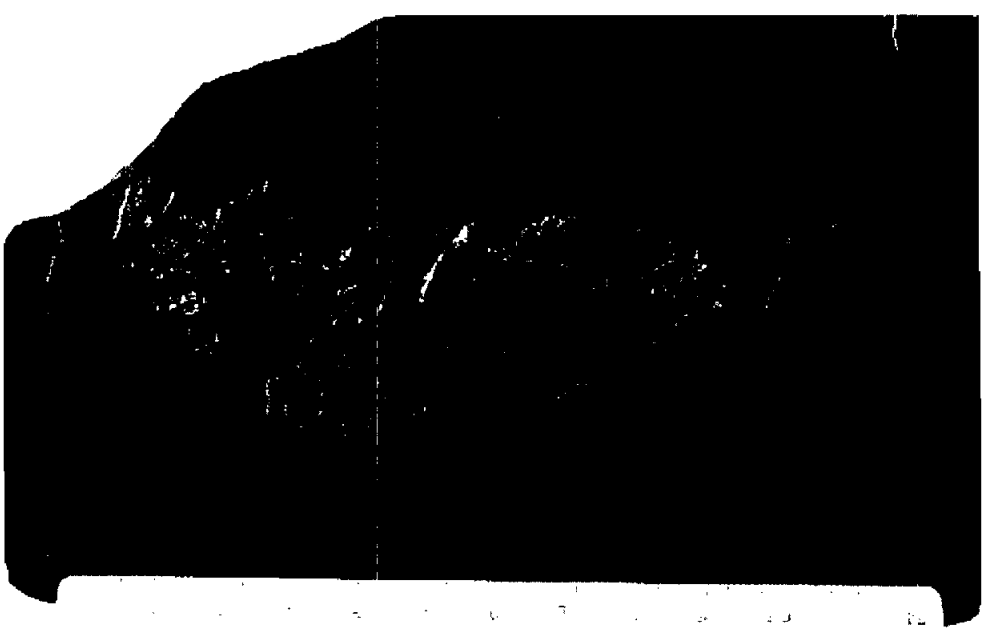


*Fig. 6: Perleidus altolepis (Val Mara, Meride, Monte San Giorgio) (Photograph Dept. Earth Sc., Univ. Milan)*

## b. Possible comparative analysis (including state of conservation of similar properties)

The Triassic palaeontological heritage of Monte San Giorgio **is unique**; a comparative analysis with other identical or similar sites is therefore not possible. The state of conservation, research history and number of publications relating to a single fossil-bearing site; the dimensions, rarity and variety of the fossil remains (in particular the fish, marine and land-based reptiles); and the number of fossil levels have no parallel elsewhere. The Permo-Jurassic setting is an additional factor in the uniqueness of Monte San Giorgio.

There are, of course, other internationally renowned Triassic fossil-bearing sites in other parts of Europe and the rest of the world. These include the "Muschelkalk formation" in Germany, the "Otter Formation" in England, Middle Triassic formations in France, Spain and Turkey, South Africa and Angola, the "Ischigualasto-Talampaya Formation" in Argentina, and the "Gosford Formation" in Australia. However, the fossils found in these places do not bear comparison with those of Monte San Giorgio, because they are fragmentary, less diverse, less numerous and in a poor state of preservation.

In particular, Monte San Giorgio has taken on a new and special significance with the recent discovery in Guizhou Province (Southern China) of marine reptiles similar to those found at the Swiss site. Phylogenetic, palaeoclimatic, palaeo-ecological and palaeobiogeographical comparisons of the fauna of the two sites could be of vital importance in reconstructing the palaeogeographic conditions of the Tethys Sea. This gives Monte San Giorgio an **important role as the point of reference for Middle Triassic marine fauna**.

Monte San Giorgio has already been granted recognition as **one of the world's five or six principal Fossil Lagerstätten** (fossil bonanzas). It is therefore comparable, to the Jurassic palaeontological sites of Holzmaden (D) and Solnhofen (D), and the Tertiary sites of Green River (USA), Monte Bolca (I) and Messel (D). The last of these already features on UNESCO's WHL as a palaeontological site exemplifying the evolution of mammals during the Eocene Period, between 57 and 36 million years ago.

A wide spectrum of scientific opinion bears witness to the international importance and uniqueness of the Monte San Giorgio fossil-bearing deposits (see Appendix **O**).

## c. Authenticity/integrity

Monte San Giorgio is a mountainous pyramid in which geological formations from the Permian to the Jurassic periods – including Triassic formations (Fig. 4) – are more or less regularly superimposed. The fossil-bearing Triassic sediments are roughly 1000 meters thick and occupy the central part of the stratigraphic succession (Fig. 7). The rocks of the five fossil-bearing levels of Monte San Giorgio are listed below, from old to young:

- the "Grenzbitumenzone" (or Besano Formation),
- the Cava Inferiore (lower quarry) beds,
- the Cava Superiore (upper quarry) beds,
- the Cassina beds, and
- the "Kalkschieferzone"

150 years of scientific research have resulted in detailed mapping of the various strata and their contours, in particular the extent of the fossil-bearing levels. However, further discoveries have been made in recent times as a result of a more systematic, modern and global approach involving different disciplines and using new investigatory techniques, such as geo-chemistry, sedimentology, taphonomic and microfacies analysis, etc.

Disciplined management of scientific excavations, co-ordination in the preparation and study of the palaeontological specimens discovered (also see chapters **2.a.** and **3.e.**) and on-going collaboration between the university institutes and the regional, cantonal and local authorities concerned provide an absolute guarantee that the outcrops will be adequately preserved and protected in the future.

## d. Criteria under which inscription is proposed (and justification for inscription under these criteria)

Monte San Giorgio's application to be included in UNESCO's world natural heritage list fulfils the criteria set out in the *"Operational Guidelines for the Implementation of the World Heritage Convention"*. In particular, the Triassic fossil-bearing formations of Monte San Giorgio qualify as assets and objects of universal value because they are eminently representative of great events in the Earth's history, providing evidence, among other things, of the development of life on Earth and geological processes [*4a (i)*].

Monte San Giorgio fulfils the relevant conditions of integrity because the Triassic fossil-bearing formations represent

- a continuous succession within the geological period in question and are part of a wider succession and geological context,
- they are the subject of careful planning, and
- they are subject to clear legal regulation.

# 3. Description

## a. Description of property

### GEOLOGY

The Middle Triassic fossil-bearing succession of Monte San Giorgio needs to be considered and "read" in the context of the history of the Southern Alps, which – along an axis of about 30 km from Lugano to Chiasso – includes significant geological events occurring between the Carboniferous period and the present.

Taken in this context, the Triassic carbonate formations of Monte San Giorgio occupy a place between the volcanic rocks (andesites and rhyolites) of the Permian period (exposed on the northern slope of the mountain) and the Jurassic rocks of the Arzo-Tremona-Besazio-Rancate area.

More particularly, the Triassic formations display a great wealth of lithological features: continuous changes in the conditions of sedimentation, due to successive phases of transgression and regression and the formation of different environments, have resulted, at different periods, in the deposition of rocks of various kinds:

- conglomerates and sandstones belonging to the Scythian-Anisian stages (Bellano or Servino Formation),
- reef limestones, dolomites and bituminous shales belonging to the Anisian and Ladinian stages [Salvatore Dolomite, "Grenzbitumenzone" or Besano Formation, San Giorgio Dolomite, Cava inferiore beds, Cava superiore beds, Cassina beds, Meride limestone and "Kalkschieferzone"],
- marls, limestones and gypsum (Pizzella marls or Raibl beds),
- massive dolomites belonging to the Norian stage (Principale Dolomite) and, finally,
- more or less dolomitised oolitic limestones belonging to the Rhaetian stage (Tremona beds).

These sedimentary formations are superimposed one on the other, from North to South, forming a Triassic rock complex more than 1000 m thick.

The present inclination of the beds at Monte San Giorgio is due to the Alpine orogeny. The mountain now appears as a dip slope with beds emerging in a south/south-westerly direction. It disappears, in the region of Rancate-Ligornetto-Stabio, under sediments of the Tertiary period and the even thicker Quaternary deposits of the Po Valley.

Fuller details of the geology of Monte San Giorgio can be found in the publications of KUHN-SCHNYDER (1963), BERNOULLI AND WIEDENMAYER (1967), KÄLIN and TRÜMPY (1977), the CANTONAL MUSEUM OF NATURAL HISTORY (1990) and in FELBER et al. (2000).

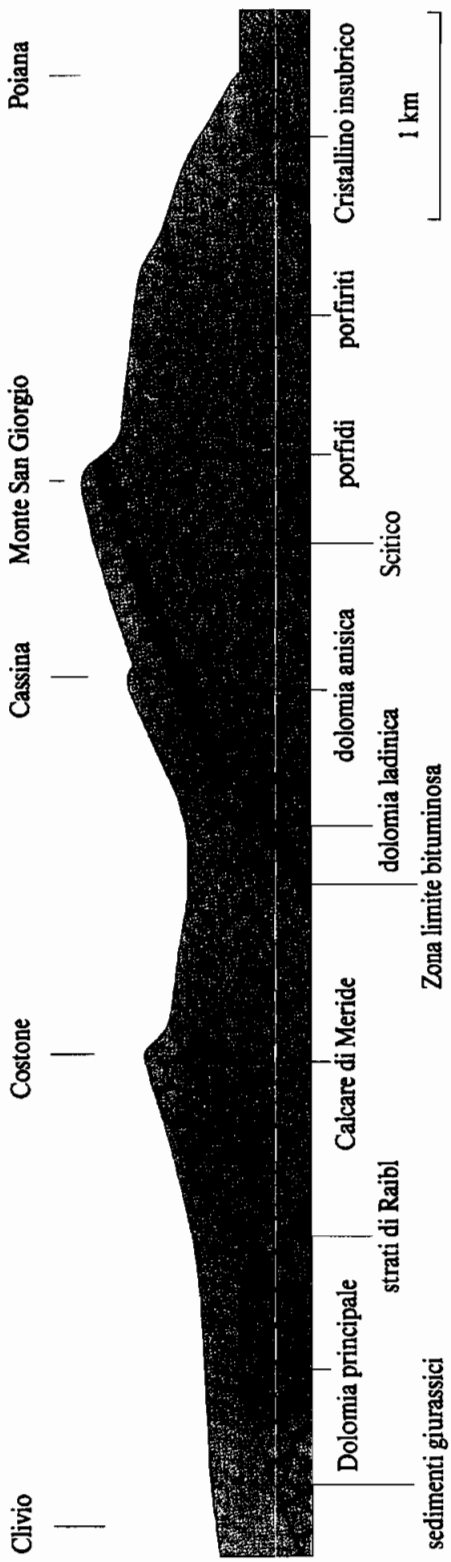



*Fig. 7: Geological section of Monte San Giorgio (from KUHN-SCHNYDER 1963, mod.).*

## PALAEONTOLOGY

The Middle Triassic formations of Monte San Giorgio consist of 5 different fossil-bearing levels, superimposed one on another (see chapters **2.a.**, **2.c.** and Fig. 10).

The best-known horizons are those of "Grenzbitumenzone" (or Besano Formation), which was the first to be studied (as early as 1800), and was exploited industrially for the production of Ichthyol during the second half of the 19$^{th}$ century and, more intensively, in the first half of the 20$^{th}$ century. Most of the spectacular palaeontological discoveries have been made in the "Grenzbitumenzone", which has yielded the largest and most visually attractive specimens. The specimens found in the four younger horizons as the Cava inferiore, Cava superiore, Cassina beds and the "Kalkschieferzone" have been less spectacular but are nevertheless of great scientific interest (mainly fish and small reptiles including embryos, but also insects).

The first scientific treatise on the fossil vertebrates of the San Giorgio area was published in 1847 by GIULIO CURIONI, who was special interested in fish. Since that time, almost 800 publications have appeared dealing with the wealth of vertebrate and invertebrate fossil fauna to be found in the locality (see appended bibliography).

The most interesting discoveries occurred later, following excavations undertaken in the Besano area by the Italian Society of Natural Sciences and the Milan Civic Museum in 1863, under the direction of ANTONIO STOPPANI, and an 1878 campaign in the same area, funded largely by the Milan Civic Museum and led by EMILIO CORNALIA. These campaigns resulted in the recovery of the remains of various ichthyosaurs, many fish, ammonites and bivalves. The Besano ammonoids were studied in 1882 by E. MOJSISOVICS. In 1886, BASSANI described two new reptiles *Ichthyosaurus cornalianus,* now called *Mixosaurus cornalianus,* and *Tanystropheus longobardicus.*

*Fig. 8: Scientific excavation at Point 902*, c. 1960 (Monte San Giorgio), *(Photograph: Pal. Inst. Univ. Zurich)*

| | | | Middle-Triassic fossil-bearing levels of Monte San Giorgio | | | | |
|---|---|---|---|---|---|---|---|
| | | | | Meride limestones | | | |
| **Excavation site** | **Research institute** | **Period** | **"Grenzbitu-menzone"** | **Cava Inferiore beds** | **Cava Superiore beds** | **Cassina beds** | **"Kalkschiefer-zone"** |
| | | | | | | | |
| Besnasca/Ca' del Frate) | DISTMI | 1990-1999 | | | | | x |
| Rio Ponticelli sopra Besano | MSNMI | 1975-1984 | x | | | | |
| Selva Bella mine at Besano | MSNMI | 1930s | x | | | | |
| Besano-Rio Vallone | MSNMI | 1863, 1878 | x | | | | |
| Sasso Caldo sopra Porto Ceresio | MSNMI | In progress since 1985 | x | | | | |
| Crocifisso-Acqua ferruginosa | PIMUZ | 1936-1938 | | x | | | |
| Crocifisso-Road to Serpiano | PIMUZ | ? | | | | x | |
| Serpiano-Tre Fontane mine | PIMUZ | 1924, 1927 | x | | | | |
| Valle Stelle | PIMUZ | 1983-1989 | x | | | | |
| Monte San Giorgio-Point 902/Mirigioli | PIMUZ | 1950-1968 | x | | | | |
| Val Porina mine | PIMUZ | 1924, 1925, 1929-1933 | x | | | | |
| Bassa Val Porina | PIMUZ | 1930, 1941 | | x | | | |
| Cassina | PIMUZ | 1933, 1937, 1971-1973, 1975 | | | | | |
| Val Serrata-Don Luigi | PIMUZ | 1930 | x | x | | | |
| Val Serrata-Cassinello | PIMUZ | 1938 | x | x | | | |
| Val Serrata-Bögia | PIMUZ | 1927, 1935, 1976 | | | | x | |
| Crocifisso-Acqua del Ghiffo 1, lower quarry | PIMUZ* | 1927 1995-1996* | | x | | | |
| Crocifisso-Acqua del Ghiffo 2, upper quarry | PIMUZ* | 1928 1997-2001* | | | x | | |
| Val Mara (Roggio I) | PIMUZ* | 1994 | | | | | x |
| Val Mara (Roggio II) | PIMUZ* | 1994 | | | | | x |
| Val Mara (Roggio III) | PIMUZ* | 1971, 1994* | | | | | x |
| Meride-Val Mara (sup.) | DISTMI* | 1996-2001 | | | | | x |

* in collaboration with the MCSNLU

**MSNMI** Museo civico di storia naturale di Milano (Milan Civic Museum of Natural History)
**PIMUZ** Palaeontological Institute and Museum of the University of Zurich
**DISTMI** Dipartimento di Scienze della Terra dell'Università di Milano (Department of Earth Sciences, University of Milan)
**MCSNLU** Museo cantonale di storia naturale di Lugano (Cantonal Museum of Natural History, Lugano)

*Fig. 9: List of fossil-bearing localities on Monte San Giorgio, subdivided by excavation site [Data reprocessed; source: GENTILINI in FELBER et al., 2000, and PIMUZ (FURRER and RIEBER, unpublished)]*

This work was followed by several geological and palaeontological studies, mainly by researchers from Northern Italy: REPOSSI and TARAMELLI (1902), DE ALESSANDRI (1910, 1913), AIRAGHI (1912, 1915). Exploitation of bituminous shales at the Tre Fontane mine, begun in 1907, brought to light further fossil remains of marine saurians, fish and molluscs.

Unfortunately, all this fossil material was lost in the destruction of the Milan Museum of Natural History, which was bombed in 1943. All that was saved of these historical collections were a few specimens that had fortunately been loaned for study purposes to the Zurich Museum.

On the Swiss side, as part of the 1919 annual conference of the Swiss Society of Natural Sciences, a visit was organised to the Ichthyol production plant at the Spinirolo factory. To their amazement, the visitors saw that the bituminous material ready for processing contained some very interesting fossil remains. This triggered a series of research and excavation campaigns, undertaken by BERNHARD PEYER from the University of Zurich, to investigate the outcrops of the "Grenzbitumenzone" on Swiss territory and the bituminous levels of the Meride Limestone formation. These have continued from 1924 to the present day, with more than 50 excavation campaigns undertaken at twenty or so different sites.

On the Italian-facing slope of Monte San Giorgio, the Milan Civic Museum began a new phase of palaeontological research at Besano in the 1950s, and subsequently at Rio Ponticelli (1974) and Sasso Caldo (1985), while the Department of Earth Sciences of the University of Milan began investigating the Ca' del Frate deposit (Viggiù) in the 1980s.

The palaeontologist BERNHARD PEYER from the University of Zurich was the first person to undertake research in the area of Serpiano and Meride. In 1924, he discovered a specimen of *Cyamodus hildegardis* (Placodontia) and several complete *Mixosaurus* (Ichthyosauria) skeletons at Valporina, within the "Grenzbitumenzone". In the same year, a 4-meter long skeleton of *Paranothosaurus amsleri* (Sauropterygia) was found at the Tre Fontane ("Grenzbitumenzone"). Later, in 1927, PEYER found another ichthyosaur, 2.5 metres in length at the Tre Fontane ("Grenzbitumenzone"), and in 1933 the same mine yielded a "long-necked saurian", *Tanystropheus longobardicus* (Protorosauria), 4.2 meters in length. 1933 also saw the sensational discovery of a land-based saurian, *Ticinosuchus ferox* (Thecodontia) at Valporina ("Grenzbitumenzone") and a specimen of *Ceresiosaurus calcagnii* (Sauropterygia),

2.3 metres in length, at the Cassina site (lower levels of the Meride Limestone). In 1936, a complete specimen of *Paraplacodus broilii* (Placodontia) was dug from the Tre Fontane mine ("Grenzbitumenzone") and, the following year, a skeleton of *Askeptosaurus italicus* (Thalattosauria) was discovered at the same site.

Excavations at the Mirigioli site, also known as Point 902 (or simply P. 902), were begun in 1950, with annual campaigns continuing until 1968 under the leadership of EMIL KUHN-SCHNYDER. Over an area of 240 $m^2$, some thirty fossil-bearing bituminous levels alternating with dolomite were studied, to a total depth of approximately 16 metres. These yielded an extraordinary quantity and variety of specimens. For instance, in stratum n. 113, which was 8.5 cm thick, the researchers discovered 62 *Mixosaurus* skeletons, about eighty small bony fish and some larger ones, such as *Saurichthys, Colobodus*, *Birgeria* and remains of coelacanths (Crossopterygii). The most interesting fossil reptiles have been studied by WILD (1974), RIEPPEL (1989), SANDER (1989) BRINKMANN (1998), fish by SCHWARZ (1970), RIEPPEL (1981), BÜRGIN (1992) and MUTTER (1999).

In other beds, many bivalves of the genus *Daonella* genus (attributed to seven species) were discovered, showing how they had evolved over a period of at least one million years (RIEBER 1969). From a study of ammonoids, which are fairly common in the dolomite strata od the "Grenzbitumenzone", it was possible to define the border between the Anisian and Ladinian Triassic stages (RIEBER and BRACK 1993).

In 1994 the Palaeontological Institute and Museum of the University of Zurich, in collaboration with the Cantonal Museum of Natural History (Lugano), began a new series of excavations in the Val Mara below Meride and at Crocifisso, working in the "Kalkschieferzone" and the Meride Limestone strata (BÜRGIN, 1995; FURRER, 1995).

In the same area, and as a part of the same joint project, in 1996 the Department of Earth Sciences of the University of Milan investigated the upper Meride Limestone strata (the so-called "Kalkschieferzone"). These excavations on Swiss territory are a follow-up to similar investigations carried out on the Italian side in the area of Ca' del Frate. They will complete our palaeontological knowledge of the characteristics and extent of this formation, which has not received so much attention as others.

These recent campaigns have yielded many important fossils, though not so many spectacular discoveries of large saurians. As well as thousands of fish belonging to some twenty different species, discoveries during the campaigns in the Val Mara and

at Acqua del Ghiffo between 1994 and 2001 have included the first fossil insects found on Monte San Giorgio (KRZEMINSKI and LOMBARDO, 2001), a young *Ceresiosaurus* (HÄNNI, in prep.) and a *Saurichthys* with embryos (BÜRGIN, in prep.). On the Italian side, the excavations at Ca' del Frate, carried out by the University of Milan in the bituminous levels of the "Kalkschieferzone", have also brought to light some *Lariosaurus* embryos, (RENESTO et al. in prep.); but perhaps more significant are a large number of fossil fish exhibiting complex and varied palaeobiological features (TINTORI et al., 1985; TINTORI, 1992), which make an interesting comparison with those found in Switzerland (TINTORI et al., 1999; LOMBARDO and TINTORI, 1997; LOMBARDO, 1997).

| Middle Triassic levels | Crustaceans | Marine reptiles | Land-based reptiles | Cephalopods | Bivalves | Fish | Insects | Land-based plants |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| "Kalkschieferzone" | +++ | + | | | | +++ | + | +++ |
| Cassina beds | | ++ | | + | | + | | + |
| Cava Superiore beds | | ++ | | + | | + | + | + |
| Cava Inferiore beds | | ++ | | + | +++ | + | | + |
| "Grenzbitumenzone" | + | +++ | + | +++ | +++ | ++ | + ? | +++ |

+++ very abundant
++ abundant
+ rare

*Fig. 10: Distribution of most important fossil groups in the five fossil-bearing levels of Monte San Giorgio.*

| REPTILES | FISH | *Dipteronotus ornatus* |
|---|---|---|
| | | *Dipteronotus olgiatii* |
| **Placodontia** | **CHONDRICHTHYES** | *Luganoia lepidosteoides* |
| *Cyamodus hildegardis* | *Acronemnus tuberculatus* | *Peltopleurus lissocephalus* |
| *Paraplacodus broilii* | *Hybodus* cf. *plicatus* | *P. rugosus* |
| *Helveticosaurus zollingeri* | *Acrodus georgii* | *P. notocephalus* |
| | *Asteracanthus* cf. *reticulatus* | *P. nuptialis* |
| | *Palaeobates angustissimus* | *Peltopleurus. n.* sp. B |
| **Ichthyosauria** | | *Peltopleurus. n.* sp. C |
| *Mixosaurus* cf. *cornalianus* Type A | **OSTEICHTHYES** | *Peltopleurus. n.* sp. D |
| *Mixosaurus* cf. *cornalianus* Type B | **Sarcopterygii** | *Peltopleurus. n.* sp. E |
| *Mixosaurus* cf *nordenskioeldii* | *Ticinepomis peyeri* | *Peripeltopleurusto vacillipinnis* |
| *Ichthyosaurus* gen. Indet | cf. *Holophagus picenus* | *P. hyposimosus* |
| *Mikadocephalus gracilirostris* | Coelacanthidae gen. et sp. indet. | *Peripeltopleurus* sp. |
| *Mixosaurus kunhnschnyderi* | | *Cephaloxenus macropterus* |
| *Phalorodon fraasi* | **Actinopterygii** | *Habroichthys minimuss* |
| *Wimanius odontopalatus* | *Gyrolepis* sp. | *H. griffthi* |
| *Cymbospondylus buchseri* | *Aneurolepis macroptera* | *Habroichthys* sp. |
| *Besanosaurus leptorhynchus* | *Acronemus* sp. | |
| | *Ptycholepis barboi* | **Neopterygii** |
| **Prolacertiformes** | *P. priscus* | *Eosemionotus* n. sp. A |
| *Tanystropheus longobardicus* | *P. schaefferi* | *Eosemionotus* n. sp. B |
| *Macrocnemus bassanii* | *P. magnus* | *Eosemionotus* n. sp. C |
| | *Bobasatrania ceresiensis* | *Eosemionotus* n. sp. D |
| **Archosauria** | *Saurichthys costasquamosus* | *Archaeosemionotus* n. sp. A |
| *Ticinosuchus ferox* | *S. curionii* | *Archaeosemionotus* n. sp. B |
| | *S. macrocephalus* | *Archaeosemionotus* n. sp. C |
| **Sauropterygia** | *S. paucitrichus* | *Allolepidotus bellotti* |
| *Lariosaurus sp.* | *Saurichthys* sp. | *Allolepidotus nothosomoides* |
| *Neusticosaurus peyeri* | *Birgeria stensiöi* | *Archaeosemionotus* sp. |
| *N. pusillus* | *Pholidopleurus ticinensis* | *Placopleurus minimus* |
| *N. edwardsii* | *Gracilignatichthys microlepis* | *P. primus* |
| *Ceresiosaurus calcagnii* | *Platysiagum minus* | *P. besanensis* |
| *Paranothosaurs amsleri* | *Perleidus altolepis* | *Placopleurus* n. sp. A |
| *Nothosaurus sp.* | *Perleidus sp.* | *Placopleurus* n. sp. B |
| *Lariosaurus buzzii (= L. valceresii)* | *Daninia spinosa* | *Eoeugnathus megalepis* |
| *Silvestrosaurus buzzii* | *Gen n.* A *sp. n.* | *Broughia* sp. |
| *Serpianosaurus mirigiolensis* | *Colobodus bassanii* | Parasemionotidae n. g. e n. sp |
| | *Meridensia meridensis* | *Furo* sp. |
| **Thalattosauria** | *Aetheodontus besanensis* | *Legnonotus obtusus* |
| *Askeptosaurus italicus* | *Ctenognathichthys belottii* | Macrosemiidae n. g. e n. sp. |
| *Clarazia schinzi* | *Peltolerperleidus bellipinnis* | Ophiopsidae *n.* g. e n. sp. |
| *Heschleria rübeli* | *P. elongignathus* | *Ophiopsis* cf. *lepturus* |
| | *P. macrodontus* | Pholidophoridae n. g. e n. sp. |
| | *P. triseries* | *Prohalecites porroi* |
| | | Neopterygii n. g. &. n. sp. |

*Fig. 11: List of fossil vertebrates found in the Middle Triassic formations of Monte San Giorgio [Source: BÜRGIN, 1998; TINTORI, 1998; FURRER (unpublished catalogue), various publications]*

*Fig. 12: Ticinosuchus ferox (Val Porina, Monte San Giorgio) (Photograph: Pal. Inst. Univ. Zurich)*

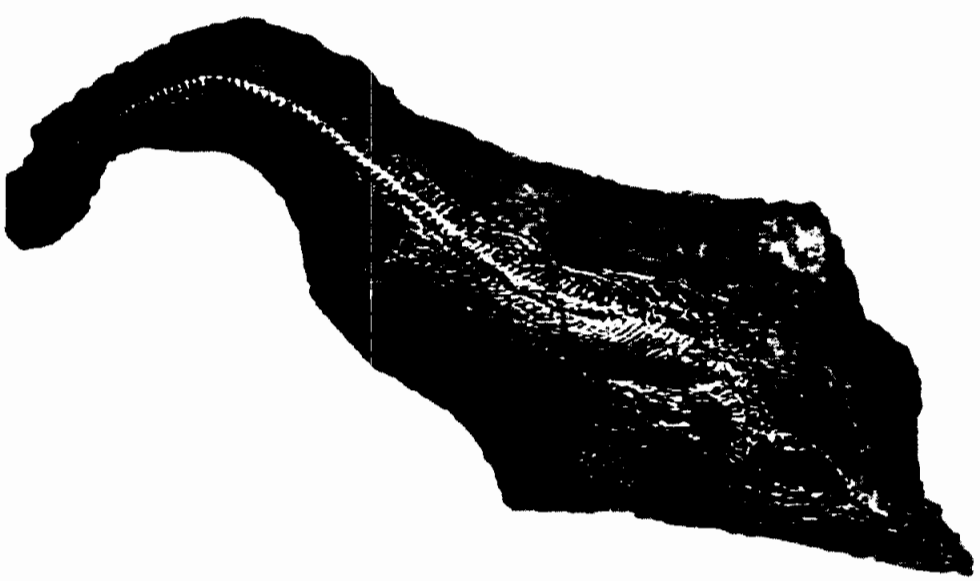


*Fig. 13: Mixosaurus cornalianus (Point 902, Monte San Giorgio) (Photograph: Pal. Inst. Univ. Zurich)*

*Fig. 14: Neusticosaurus sp. (Acqua del Ghiffo, Meride, Monte San Giorgio) (Photograph: Pal. Inst. Univ. Zurich)*

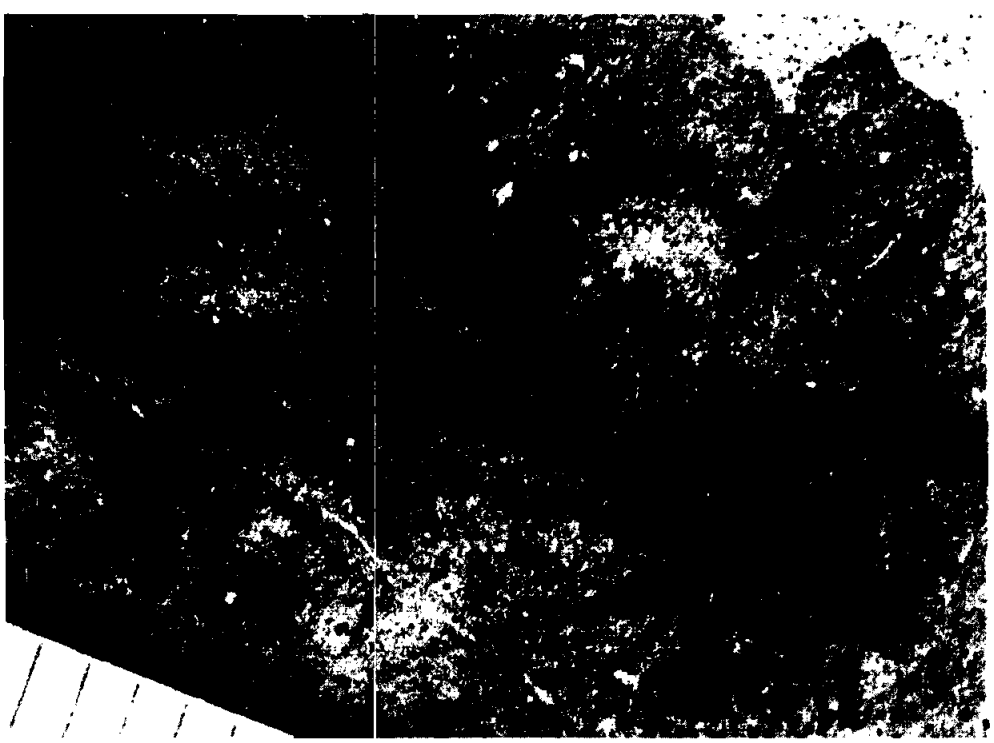


*Fig.15: "Mosquito" Tintorina meridensis (Val Mara, Meride, Monte San Giorgio) (Photograph: Dept. Earth Sc., Univ. Milan)*

## KARST PHENOMENA

The carbonate rocks of Monte San Giorgio exhibit many Karst features (COTTI and FERRINI, 1961). The area includes some thirty caves, which affect the hydrology of the mountain. Most of these caves are found in the dolomitic rocks of the Middle Triassic and therefore come within the protection area. A smaller number are situated in the buffer zone, where limestone rocks from the Jurassic period, some bearing more chert, predominate.

These Karst phenomena, together with the lithology of the sub-soil, have a strong influence on the distribution of flora (see chapter on "flora and vegetation"). They have also been significant in the human settlement of the territory, as attested not only by legend but also by items found in some of the caves in the Tremona area.

| TI | Name | Commune | Alt. | Dev. | Depth | Coordinates |
|---|---|---|---|---|---|---|
| 8 | Bögia | Meride | 750 | 350 | | 717.600/084.400 |
| 9 | Fornett I | Tremona | 590 | 17 | | 718.270/082.520 |
| 10 | Tana Bögiana | Rancate | 470 | 6 | | 718.500/081.700 |
| 13 | Tana del Beato | Meride | 1095 | 70 | | 717.250/085.850 |
| 16 | Grotta del Mago | Rancate | 360 | 24 | | 718.800/082.450 |
| 27 | Böcc da la Ratategna | Tremona | 600 | 19 | | 718.240/082.375 |
| 28 | Fornett II | Tremona | 500 | 20 | | 718.560/082.440 |
| 36 | Grotta dei Cugnoli | Meride | 1010 | 48 | -27 | 717.350/085.550 |
| 37 | La Palüscera | Meride | 935 | 40 | -24 | 717.650/084.900 |
| 43 | Buco della Fonte | Meride | 900 | 10 | | 717.175/085.050 |
| 44 | Böcc da la Vaca | Meride | 920 | 6 | -6 | 717.150/085.090 |
| 56 | Fornet III | Tremona | 500 | 20 | | 718.700/082.220 |
| 67 | Grotta del Tufo | Rancate | 450 | 24 | -9 | 718.450/082.900 |
| 90 | Crepacci di Tremola | Tremona | | | | 718.175/082.600 |
| 106 | Grotta alla Cava Caverzasio | Arzo | 565 | 70 | -12 | 716.160/081.820 |
| 107 | Grotta delle Cantine Superiori | Tremona | 590 | 50 | | 718.250/082.490 |
| 108 | Fornet IV | Tremona | 600 | 20 | -12 | 718.260/082.900 |
| 109 | Cavernetta del Torrione | Tremona | 610 | 6 | | 718.210/082.570 |
| 110 | Buco della Cascata | Riva S.Vitale | 305 | 8 | | 718.560/083.520 |
| 111 | Buco della Bustorgna | Meride | 930 | 7 | -7 | 717.600/085.025 |
| 113 | Tana del Lüff | Arzo | 500 | 7 | | 716.700/081.650 |
| 121 | Mitra del Vescovo I | Rancate | 460 | 35 | -12 | 718.680/082.485 |
| 122 | Mitra del Vescovo II | Rancate | 470 | 20 | -9 | 718.670/082.500 |
| 148 | Antro delle Streghe | Tremona | 635 | 73 | -13 | 718.120/082.750 |
| 149 | Antro del Castello | Tremona | 630 | 136 | -29 | 718.130/082.750 |
| 150 | Antro della Castellana | Tremona | 620 | 121 | -46 | 718.100/082.540 |
| 155 | Böcc da la Ratategna II | Tremona | 605 | 13 | -4 | 718.235/082.385 |
| 165 | Pozzo di alta Val Serrata | Meride | 940 | 22 | -6 | 717.050/085.300 |

*Fig. 16: List of Karst caves on Monte San Giorgio (Source: BAUMGARTNER 2001, unpublished)*

*Fig. 17: Distribution of Karst caves on Monte San Giorgio (from BAUMGARTNER 2001, unpublished); numbers according to the Ticino land register*

*Fig. 18: Grotta della Bögia (Meride, Monte San Giorgio) (Photograph: S. BAUMGARTNER)*

## FLORA AND VEGETATION

The territory we are concerned with is subject to climatic conditions of the Insubric type (high exposure to sunshine, mild winters with few frosty days, high rainfall in summer), which favour the development of a sub-Mediterranean type of vegetation. Because of the dual nature of the pedogenetic subsoil – acidic on the northern slope (rhyolites) and alkaline on the southern slope (mainly dolomites and limestones) – the vegetation of Monte San Giorgio includes both acid and lime-loving plants. Due to the favourable climatic conditions and its pedogenetic diversity, Monte San Giorgio is particularly interesting from a botanical point of view, unique in the Canton of Ticino.

The acidic soils support stands of *Castanea sativa* (Sweet chestnut) and *Quercus petraea* (Sessile oak), accompanied by *Fraxinus excelsior* (Ash) in locations of variable humidity with fairly rich soil.

The lime-rich soils support:

- mixed broadleaf woodland of *Carpinus betulus* (European hornbeam) and *Ostrya carpinifolia* (Hop-hornbeam) on damp soils of medium depth,
- mixed broadleaf woodland of warmth-loving sub-Mediterranean type, consisting of Hop-hornbeam, *Quercus pubescens* (Pubescent oak) and *Fraxinus ornus* (Flowering or Manna ash) on dry shallow soils;
- mixed woodland of *Tilia spp.* (Lime) and *Asperula taurina* on dry-to-damp soils.

The thickets of warmth-loving sub-Mediterranean trees are undoubtedly the most unusual feature, in terms of physical appearance and diversity of species.

The Inventory of Ticino dry meadows lists no less than 18 sites covering an area of 25 hectares. These are meadows associated with dry to very dry limestone sub-soils, which are home to plant populations found nowhere else in Switzerland and in some cases not found in the entire Italian southern-Alpine zone. These meadows are dominated by *Carex humilis* (dwarf sedge) or *Molinia arundinacea* (tall moor grass). There is a high level of botanical diversity, with approximately 30 species to 30 m². More than a hundred plant species have been recorded in total, 38 of which are rare, endangered or protected at cantonal or national level. Those most noteworthy include:

- *Adenophora liliifolia* ("lady bells"), which in Switzerland is only found on Monte San Giorgio;
- *Gladiolus imbricatus*, which in Switzerland is only found on Monte San Giorgio and the Poncione d'Arzo;
- *Iris graminea* (plum-scented iris) the main Swiss population of which is found on Monte San Giorgio;
- *Dorycnium herbaceum* and *Danthonia alpina*, for which Monte San Giorgio is one of the main Swiss sites.

Since 1991, the dry meadows of Monte San Giorgio have been very carefully cared for by the Ticino authorities, with financial support from the Federal Government (see chapter **4.g.**).

**FAUNA** (see also Appendix **C**)

**Vertebrates**

102 species of vertebrate are found in the Monte San Giorgio area (6 amphibians, 8 reptiles, 63 birds and 23 mammals), and this figure rises to 109 if we also consider the neighbouring lakeside sites (7 amphibians, 9 reptiles, 66 birds and 27 mammals). Of these, 37 are included in the Red List of species recognised as endangered at national level (categories 1-4, see Fig. 19), and 21 are absolutely protected under the Berne Convention (Fig. 19). For *Pitymys Savii* (Savi's pine vole), Monte San Giorgio is the only known habitat in Switzerland. The area was once also home to *Rhinolophus ferrumequinum* (the lesser horseshoe bat), a species now threatened with extinction throughout Switzerland.

The Monte San Giorgio area is especially important for the reproduction of amphibians and reptiles, since it includes six of the listed sites of national importance:

- AN 241: Meride - Stagno Roggio (2 species: an exceptional population of *Bufo bufo* and a good population of *Rana temporaria*);
- AN 343: Meride - Stagno Guana (2 species: an exceptional population of *Bufo bufo* and a good population of *Rana temporaria*);
- AN 344: Besazio/Rancate - Pozza Pavù Ronco (3 species: *Hyla intermedia*, *Rana dalmatina*, *Bufo bufo*);
- RN 83: Arzo - Cava di marmo (8 species);
- RN 87: Meride - Campagna (6 species);
- RN 90: Ligornetto - Pre Murin (5 species).

**Invertebrates**

The invertebrate fauna, though known only in part, reflects the diversity of environments found on Monte San Giorgio. Some of the most representative and best-known groups are listed below.

58 species of mollusc have been recorded to date, 18 of which are included in the Red List of species recognised as endangered at national level (categories 1-4). There are 63 species of day-flying butterflies and moths (Hesperiidae and Rhopaloceri), one third of all the species recorded in Switzerland. Particularly rare and endangered is

*Pyrgus armoricanus* (Oberthur's Grizzled Skipper), which inhabits the driest and most arid south-facing meadowlands. There are 85 species of Apioid Hymenoptera (wild bees), 111 species of Carabid Coleoptera (ground beetles), and 47 species of Orthoptera (crickets and grasshoppers), of which *Euchorthippus declivus* and *Pholidoptera littoralis insubrica*, found only in the Ticino region of Switzerland, are included in category 1 of the Red List.

Monte San Giorgio is home to more than half of the spider species observed in the dry meadows of Ticino. At the end of the 1980s, surveys found 13 that had never preciously been recorded in Ticino, 12 never before recorded in Switzerland, and 3 that were totally unknown to science. The environments harbouring the most species are uncultivated areas that have not been invaded by trees and bushes.

Mention should also be made of the large population of crayfish (*Astacus pallipes*) found in the Gaggiolo. Due to the extensive and deep Karst phenomena, especially on the southern side of the mountain, invertebrates can penetrate a large number of caves, of which the best known is the Bögia in Val Serrata, a gallery running roughly 250 m into the mountain. It harbours unique cave-dwelling populations of crustaceans and millipedes.

| | **RED LIST (cats. 1-4)** | **PROTECTED SPECIES** | **NOTES** |
|---|---|---|---|
| **Amphibians** | | | |
| *Salamandra salamandra* | 3 | Berne Conv. III | |
| *Triturus vulgaris* | 2 | Berne Conv. III | |
| *Triturus carnifex* | 3 | Berne Conv. II | |
| *Hyla intermedia* | 2 | Berne Conv. II | |
| *Rana dalmatina* | 3 | Berne Conv. II | |
| *Bufo bufo* | 3 | Berne Conv. III | |
| | | | |
| **Reptiles** | | | |
| *Podarcis muralis* | 3 | Berne Conv. II | |
| *Lacerta viridis* | 3 | Berne Conv. II | |
| *Natrix natrix* | 3 | Berne Conv. III | |
| *Natrix tessellata* | 2 | Berne Conv. II | |
| *Coluber viridiflavus* | 3 | Berne Conv. II | |
| *Elaphe longissima* | 3 | Berne Conv. II | |
| *Coronella austriaca* | 3 | Berne Conv. II | |
| *Vipera aspis* | 3 | Berne Conv. III | |
| | | | |
| **Birds** | | | |
| *Accipiter gentilis* | 3 | Berne Conv. II | |
| *Accipiter nisus* | 3 | Berne Conv. II | |
| *Falco tinnunculus* | 3 | Berne Conv. II | |
| *Coturnix coturnix* | 3 | Berne Conv. III | |
| *Phasianus colchicus* | 3 | Berne Conv. III | |
| *Streptopelia turtur* | 3 | Berne Conv. III | |
| *Cuculus canorus* | 3 | Berne Conv. III | |
| *Caprimulgus europaeus* | 2 | Berne Conv. II | |
| *Apus melba* | 3 | Berne Conv. II | |

| | | | |
|---|---|---|---|
| *Jynx torquilla* | 3 | Berne Conv. II | |
| *Phoenicurus phoenicurus* | 3 | Berne Conv. II | |
| *Saxicola torquata* | 3 | Berne Conv. II | |
| *Monticola saxatilis* | 3 | Berne Conv. II | 1980s (Lardelli) |
| *Hippolais polyglotta* | 3 | Berne Conv. II | 1980s (Lardelli) |
| *Oriolus oriolus* | 3 | Berne Conv. II | 1980s (Lardelli) |
| *Emberiza cirlus* | 2 | Berne Conv. II | |
| | | | |
| **Mammals** | | | |
| *Muscardinus avellanarius* | 3 | Berne Conv. III | |
| *Crocidura suaveolens* | 3 | Berne Conv. III | |
| *Talpa caeca* | 4 | - | |
| *Mustela nivalis* | 3 | Berne Conv. III | |
| *Pitymys multiplex* | 3 | - | |
| *Pitimys savii* | 4 | - | Only habitat in Switzerland |
| *Lepus europaeus* | 3 | - | |

*Fig. 19: Vertebrate species included in the Swiss "Red List" (degree of endangerment at national level: cats. 1-4; DUELLI et al., 1994) and listed in appendixes II and III of the Berne Convention.*

## FUNGI

The Monte San Giorgio area is of such enormous interest from a mycological point of view that experts refer to it as a "mycological sanctuary".

Of the 554 (!) species of fungi found to date on the mountain, no less than 130 come only from this part of Ticino, while 5 (*Boletus xanthocyaneus*, *Cortinarius boudieri* v. *pseudoarcuatus*, *Cortinarius pelargoniobtusus*, *Lepiota forquignoni*, *Lycoperdon velatum*) are found in Switzerland only at Meride. Of these 554 species, 2 (*Hygrocybe calyptriformis, Verpa conica*) are protected by the Federal Ordinance on the Protection of Nature and Preservation of National Heritage and 19 feature in the provisional Red List of Switzerland's endangered macromycota species (Fig. 20). The latter are associated with warmth-loving broadleaf woodland on basic soils, poor grassland and the alder species *Alnus glutinosa*. Specially significant is the wealth of *Boletus* species: an exhibition of fungi held in the 1970s featured no less than 44 species from the Serpiano area alone (some 130 species have been described for Europe as a whole), including such rare species as *Boletus dupainii*, which is typical of warmth-loving broadleaf woodland on basic soils and fruits only every 4-5 years, and *Xerocomus moravicus*, a species included in the Red List.

It is also worth mentioning that, in 1979, a species previously unknown to science (*Tricholoma basirubens*) was discovered at Meride.

| Species | Habitat |
|---|---|
| *Aleurodiscus disciformis* (DC.: r.) Pat | elm trunk |
| *Boletus queletii* Schulzer | broadleaf, basic soil |
| *Calocybe ionides* (Bull.: Fr.) Donk | broadleaf, basic soil |
| *Cortinarius bibulus* Quél | *Alnus glutinosa* litter |
| *Cortinarius cumatilis* Fr. | broadleaf woodland |
| *Cortinarius orellanus* Fr. | broadleaf woodland |
| *Entoloma bloxamii* (Berk. & Broome) Sacc. | poor grassland |
| *Guepiniopsis buccina* (Pers.: Fr.) L.L. Kenn. | broadleaf branches |
| *Gyrodon lividus* (Bull.: Fr.) Sacc. | *Alnus glutinosa* |
| *Hericium erinaceum* (Bull.: Fr.) Pers | broadleaf branch |
| *Hygrocybe calyptriformis* (Berk. & Broome) Fayod | poor grassland |
| *Hygrocybe intermedia* (Pass.) Fayod | poor grassland |
| *Hygrocybe quieta* (Kühner) Singer | poor grassland |
| *Hygrocybe reidii* Kühner | broadleaf, basic soil |
| *Lactarius controversus* (Pers.: Fr.) Fr. | broadleaf, basic soil |
| *Pulcherricium caeruleum* (Schrad.: Fr.) Parmasto | broadleaf branches |
| *Tricholoma acerbum* (Bull.: Fr.) Quél. | beech |
| *Verpa conica* Sw.: Pers. | broadleaf woodland |
| *Xerocomus moravicus* (Vacek) Herink | broadleaf, basic soil |

*Fig. 20: Species of fungi found on Monte San Giorgio which are included in the provisional Red List of Switzerland's endangered macromycota.*

## b. History and Development

This chapter is concerned with the history of human activity on Monte San Giorgio, from the Neolithic Period to the late Middle Ages, and with the quarrying, mining and scientific research activities of more recent times.

### ARCHAEOLOGICAL NOTES

During the Neolithic Period, what is now the Canton of Ticino must have been densely wooded, supporting a wealth of wildlife. The area was slowly settled by human beings, who gradually developed from hunter gatherers – as they must have been 6,000 to 6,500 years ago – into sedentary farmers and herdsmen.

Archaeological finds indicate that humans have been present on Monte San Giorgio since Neolithic Times, and human settlement has continued to the present day.

There is documentary evidence that, in the early nineteenth century, an enormous quantity of flints was found near the lake at Riva San Vitale. This would seem to indicate that the area had been penetrated by groups of colonisers from the Po Valley, where there were already significant lake-side settlements.

Some of the items brought to light at Tremona are also from the Neolithic Period. Archaeological excavations in this area – begun in the 1990s at Castello – reveal a continuous pattern of settlement up to the late medieval period.

However, the most striking archaeological finds in the area date from Roman times. At Riva San Vitale, the discoveries include tombs, stones bearing inscriptions, locally produced bricks, and evidence that fishing and craft activities were carried on, as well as livestock farming. Artefacts from the Roman period have also been found at Besazio, Brusino Arsizio and Meride, though the circumstances in which they were used is not always clear.

As regards the early medieval period, Riva San Vitale is famous for its early Christian baptistery (5th century) and has also yielded a series of tombs containing grave goods. These include a gilded bronze Byzantine buckle, now kept in the Museo della Casa Arcipretale. A dig inside the parish church of Sant'Antonino at Besazio has also brought to light seven tombs from the Lombard period, containing brooches, belt buckles, ferrules and other items, now exhibited at the Castello di Montebello, Bellinzona (World Heritage Site). The tombs found at Arzo date from the late medieval period.

Ruins and place names – as at Brusino Arsizio, Meride or Tremona – are probable evidence of medieval strongholds, which have been destroyed or converted to other uses over the centuries.

## THE BITUMINOUS SHALE MINES

The bituminous shales of the Monte San Giorgio area must have been known for centuries on account of their high oil content, which made them burn easily. However, it was not until the mid-eighteenth century that, as a result of a shortage of fuel for furnaces, the Milanese government encouraged a search for fossil fuels in the valleys of Lombardy. This was why, between 1774 and 1790, a certain VALSECCHI from Lecco resumed excavations in an old mine at Besano, on the Italian side. This is the earliest information we have of industrial mining activity in the rocks of Monte San Giorgio.

The first technical investigations of the bituminous shales, dating from 1830, were performed with a view to extracting gas to light the streets of Milan. But the excavations, carried out for this purpose above Besano, were soon abandoned. This initiative was followed by others, always with the aim of obtaining fuel, but all efforts were unsuccessful because the oil content was not high enough. The right to exploit the bituminous deposits discovered on the Swiss side was assigned by the cantonal government to ANTONIO DE MARTINI, a native of Como, in 1856. This was the beginning of a thirty-year saga of transfers of claims, renewals of licences, appeals, disputes and mistrust, but no concrete results.

The search for bituminous shales was given a decisive boost by the commercial success of Ichthyol (sulphoichthyolate of ammonia), obtained from oil extracted from the bituminous shales of Seefeld in the Austrian Tyrol, which was used for treating skin conditions (eczema). The pioneers of its production on Monte San Giorgio were GIUSEPPE RATTI then, in 1906, the chemist PIERO NERI SIZZO DE NORIS, who founded the Società Anonima Miniere Scisti Bituminosi di Meride e Besano [Meride and Besano Bituminous Shale Mining Company] and built the Spinirolo plant for distilling the shale oil and refining Saurol, a product akin to Ichthyol, supplied to the Milan and Basle pharmaceuticals markets.

By 1916, there were five mines operating in the Tre Fontane area, with a total development of 900 m; by the early 1940s, roughly 1,700 m of tunnels and risers had been dug. The average annual production of oil-bearing material was around 300-400 tons, equivalent to 22-30 tons of unrefined oil. Production of Saurol declined during World War II, but recovered in the post-war period, though only for a few years. At this time, the mining company employed about 30 miners and production staff. Eventually, there were few remaining customers, most of them in the veterinary pharmaceuticals sector overseas. Mining activities ceased in the early 1950s and the company went into liquidation soon afterwards.

All that remains of this industrial enterprise, in which the local population was closely involved (they were also employed in other mining activities, particularly in quarrying ornamental stone) are a few mine shafts in the Serpiano area and, above all, the old Spinirolo plant, a fine exarnple of industrial architecture, now converted into a cultural and holiday centre.

*Fig. 21: Label from a bottle of "Saurolo"*

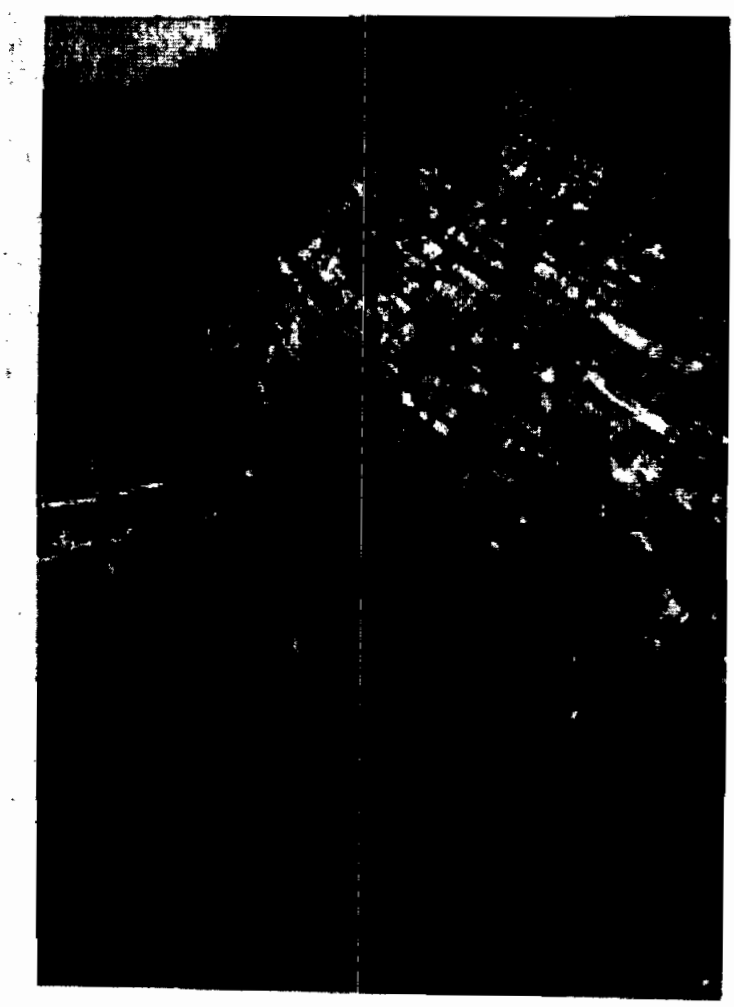


*Fig. 22: Workmen at the Tre Fontane mine (Monte San Giorgio)*

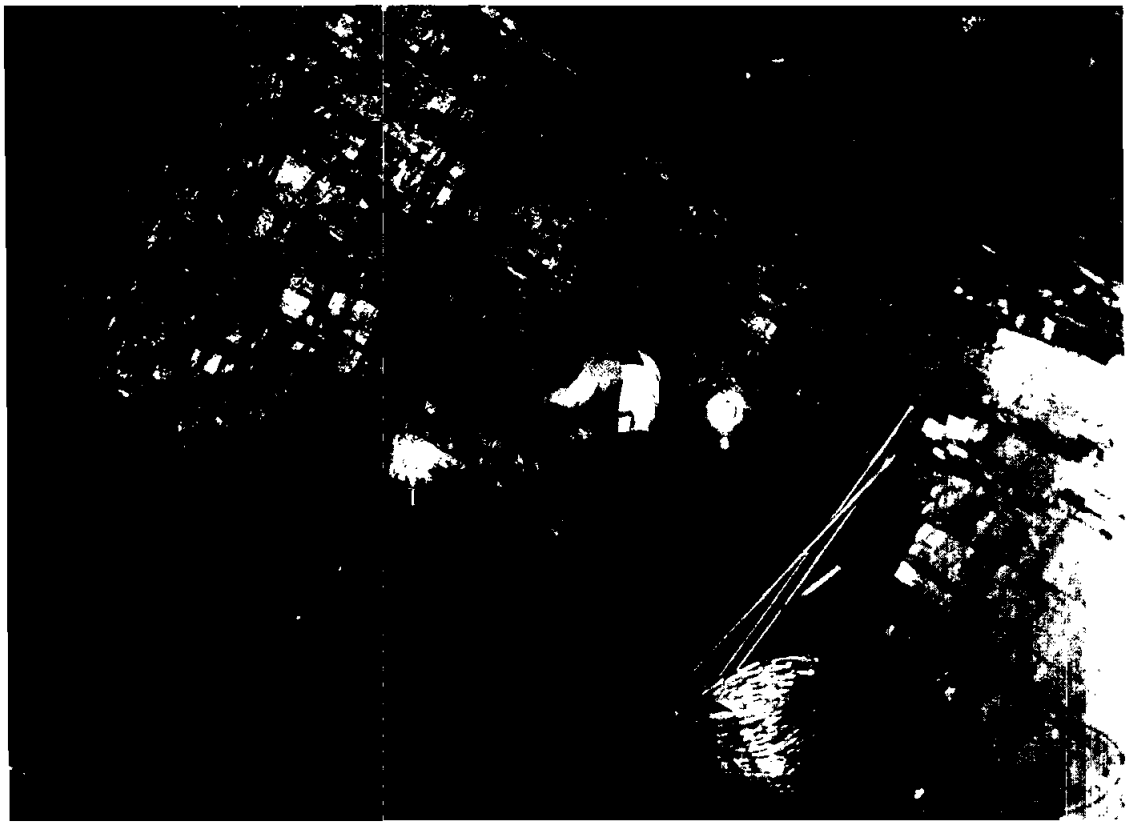


*Fig. 23: Stone quarries at Serpiano (Monte San Giorgio)*

*Fig. 24: The Spinirolo plant at Meride (Photograph: M. FELBER)*

## THE HISTORY OF PALAEONTOLOGICAL EXCAVATIONS

Scientific investigations began at the same time as industrial activity in the area. There were sporadic excavations from as early as 1863, but it was not until 1924 that systematic scientific campaigns were undertaken in areas unconnected with mining. The excavations undertaken by the Palaeontological Institute and Museum of the University of Zurich, the Milan Museum of Natural History and the Department of Earth Sciences of the University of Milan are described in detail in the chapter on Palaeontology, as are some of the many sensational finds (see Fig. 8).

Since the early 1990s, further excavations have been undertaken in the less obviously fossil-bearing and less thoroughly investigated formations of Monte San Giorgio. Although these have not yielded large reptiles several meters in length, as in the past, they have resulted in the discovery of species unknown to science, especially fish and insects. At the same time, new investigatory techniques and a multi-disciplinary approach have improved understanding of the genesis and evolution of the fossil environments of the sedimentary sequence of Monte San Giorgio.

Only the approved university institutes are permitted to search for fossils on Monte San Giorgio; amateurs and the general public are forbidden to do so by law [Legislative Decree governing the collection of rocks, mineral and fossils (1974) and related Regulations regarding its implementation (1975, amended 1995)].

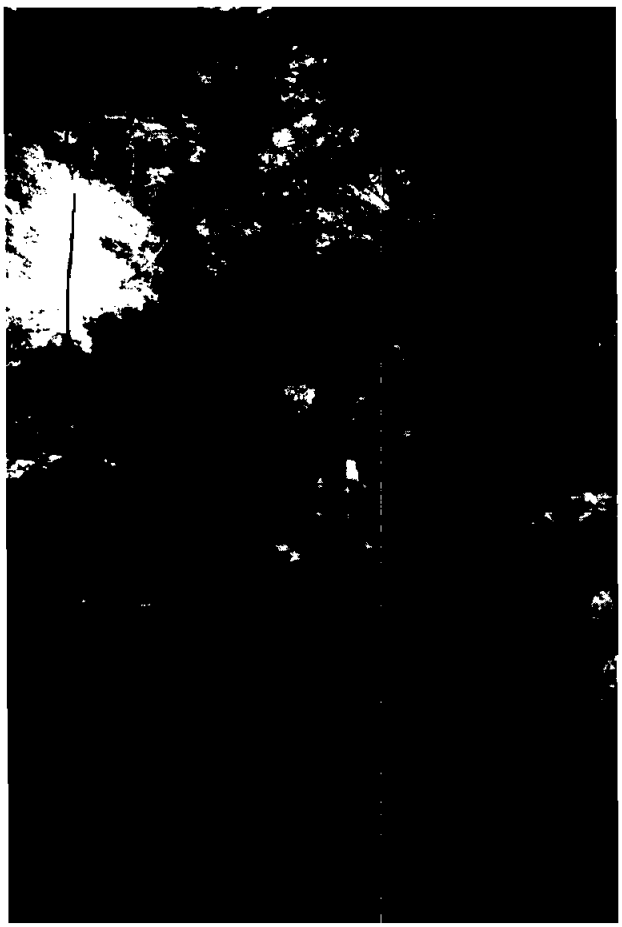


*Fig. 25: Excavation undertaken in 2000 by the Department of Earth Sciences of the University of Milan in Val Mara (Meride, Monte San Giorgio) (Photograph: M. FELBER)*

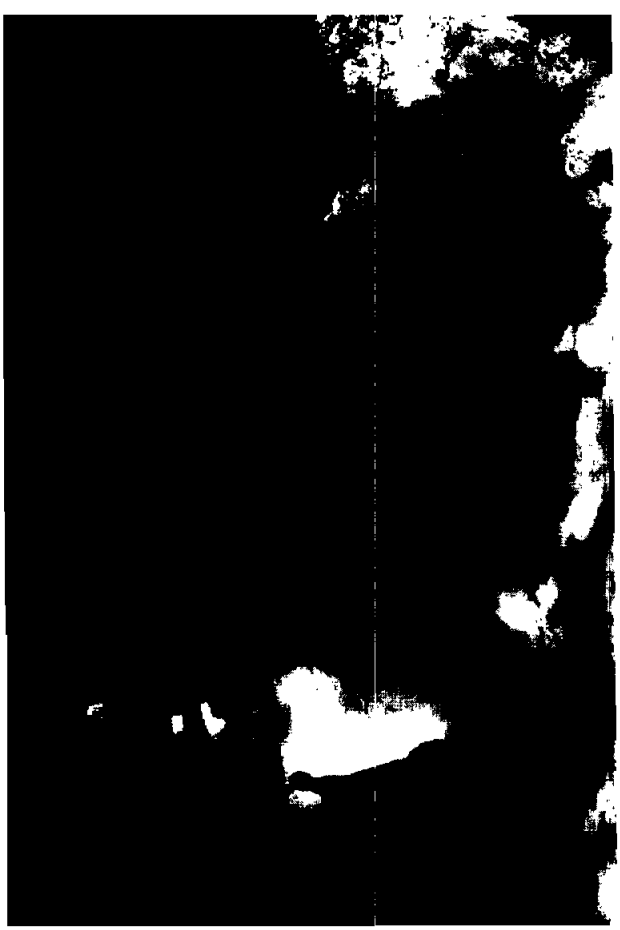


*Fig. 26: Excavation undertaken in 2000 by the Palaeontological Institute and Museum of the University of Zurich at Acqua del Ghiffo (Meride, Monte San Giorgio) (Photograph: M. FELBER)*

## c. Form and date of most recent records of property

The wealth of scientific, educational and more popular literature relating to the site – almost 800 titles in all – is listed in a separate Appendix **A**. Study of the materials catalogued in the collections of the Zurich and Milan institutes, and in particular the new wave of excavations beginning in the early 1990s, have given rise to a new series of publications dealing with recent discoveries of new species and the evolution of particular species and groups.

Prominent among these works are the original scientific contributions published over the last decade or so by the universities of Zurich and Milan: BRACK and RIEBER (1993, 1996); BRINKMANN (1996, 1997); BÜRGIN (1990, 1992, 1995, 1998); BÜRGIN et al. (1989); FURRER (1995, 1999); Hänni (1999), KUHN-SCHNYDER (1990, 1994); LOMBARDO (1995, 1997, 1998, 1999); LOMBARDO and TINTORI (1997); LOMBARDO et al. (1998); Mutter (1998, 1999), PINNA (1990, 1991, 1992); PREMRU (1991); RENESTO (1990, 1991, 1993, 1994); RIEBER (1990); RIEPPEL (1989, 1995); RIEPPEL and KEBANG (1995); RIEPPEL and WILD (1996); SANDER (1989, 1990, 1997); SANDER and MAZIN (1993); TINTORI (1990, 1991, 1992, 1995, 1997, 1998, 1999); TINTORI and LOMBARDO (1998, 1999); TINTORI and BRAMBILLA (1991); TINTORI and RENESTO (1990, 1993); TINTORI et al. (1990, 1995); TSCHANZ (1990).

The palaeontological investigations and interpretation of the evolution of the Middle Triassic environment of Monte San Giorgio have also been supported by research in the fields of sedimentology, geochemistry and geomineralogy: BERNASCONI (1991, 1992, 1994); BERNASCONI and RIVA (1990); BIONDA (1996); BRACK and RIEBER (1990); BRACK et al. (1996); FURRER (1995), MUNDIL et al. (1994); NERI et al. (1996); NERI and ROSSI (1993); OPPIZZI et al.(1999), ROEHL et al. (2001).

The educational and popularising contributions include articles by FELBER (1991); FELBER et al. (1997) and FURRER (1991, 1995, 1996, 1998), and in particular the GEO-GUIDE to Monte San Giorgio (see Appendix **L**), the first of its kind in Switzerland, by FELBER, GENTILINI, FURRER and TINTORI (2000).

Recently produced inventories and lists of plant and animal species (1990-2000) are appended separately (Appendix **C**).

## d. Present state of conservation

The legal provisions governing the protection of the area and planning matters are set out in chapters **4.b.** and **4.f.** below.

The state of conservation of the site is satisfactory and no part of the protection area is threatened by immediate or foreseeable dangers. Human pressures on the natural environment of Monte San Giorgio – in particular the palaeontological components – are minimal and do not give rise to any particular conflicts, because the area is largely in its natural state and uninhabited, and is subject to a variety of protection measures.

A vital aspect of such protection is the Legislative Decree governing the search for and collection of rocks, minerals and fossils (1974), whereby a cantonal authorisation is required in order to collect rocks, mineral and fossils. Under the Regulations implementing this decree, permission to carry out research may only be granted to university institutes or scientific researchers with a proven track record. Since the law came into force, there have been no departures from these stipulations, and permits have been granted only to the Palaeontological Institute and Museum of the University of Zurich and the Department of Earth Sciences of the University of Milan, so as to avoid any dispersion of the important fossil remains in question.

For this reason the Middle Triassic palaeontological heritage of Monte San Giorgio has been preserved and catalogued almost in its entirety in the collections and exhibition of the Paleontological Institute and Museum of the University of Zurich, whose Museum is the main point of attraction. However, the discoveries made during recent campaigns are kept at the Cantonal Museum of Natural History in Lugano. Finds made on the Italian side are conserved in museums in Milan, Induno Olona and Besano.

Only a very small percentage of the fossils from Monte San Giorgio (estimated figure 1-2%) have found their way to other Swiss, European or overseas museums. This makes the Middle Triassic palaeontological deposits of Monte San Giorgio quite exceptional in international terms.

## e. Policies and programmes related to the presentation and promotion of the property.

The university institutes and their related museums (the Zurich Institute and Museum of Palaeontology; the Milan Civic Museum of Natural History; and the Lugano Museum of Natural History, representing the Ticino Department of Land Use and Environment),

in conjunction with the local authorities, are now making a major effort to co-ordinate their excavation campaigns and to disseminate scientific information acquired on the ground, which would otherwise only be available to a restricted circle of specialists.

In addition, the regional museums of Meride, Besano and Induno Olona, wanting to promote greater awareness of their areas, have recently shown considerable commitment to making the palaeontological heritage of Monte San Giorgio better known locally. A good example of this work is the publication of a GEO-GUIDE to Monte San Giorgio (see below) which combines factual information, interviews and geopalaeontological and geomineral historical documentation, some of which was obtained as a result of an employment programme organised by the Cantonal Museum of Natural History.

This wealth of data, supplemented with contributions from the Meride Fossil Museum, the Varese provincial authorities, the universities of Zurich and Milan, the Milan Museum of Natural History and the people of Meride, is soon to be published in **illustrated book** form by the earth science magazine GEOLOGIA INSUBRICA. It will be an important source of historical, technical and scientific information, documenting the development of stone quarrying in the area and the palaeontological excavation campaigns.

Many other collaborative ventures are also under way, involving cross-border organisations seeking to achieve common objectives in the cultural, educational and tourism fields. These include improving the information provided by local museums, establishing data-exchange networks, publishing geo-guides, laying out educational nature trails on specific themes, opening up excavations sites for public visits, recovering and exhibiting mining equipment and other aspects of industrial archaeology (furnaces, old quarries, etc.), guided tours, training courses, conferences, etc.

With this in mind, in May 2001 the local authorities in the Swiss part of Monte San Giorgio (Meride, Brusino Arsizio, Arzo, Tremona, Riva San Vitale, Rancate, Besazio, Ligornetto and Stabio), those on the Italian side (Besano, Porto Ceresio, Viggiù, Saltrio and Clivio) and a number of private and public-sector organisations (Friends of the Mountain Park [Associazione Amici del Parco della Montagna], the provincial government of Varese, the Valceresio Mountain Community [Comunità Montana Valceresio] and the Varese Tourism Board) signed a *"**Draft agreement** (...) to define a joint programme of integrated development to promote the environmental, historical,*

*economic and touristic aspects of the area, (...) and to put into effect an organic plan for this purpose (...)".*

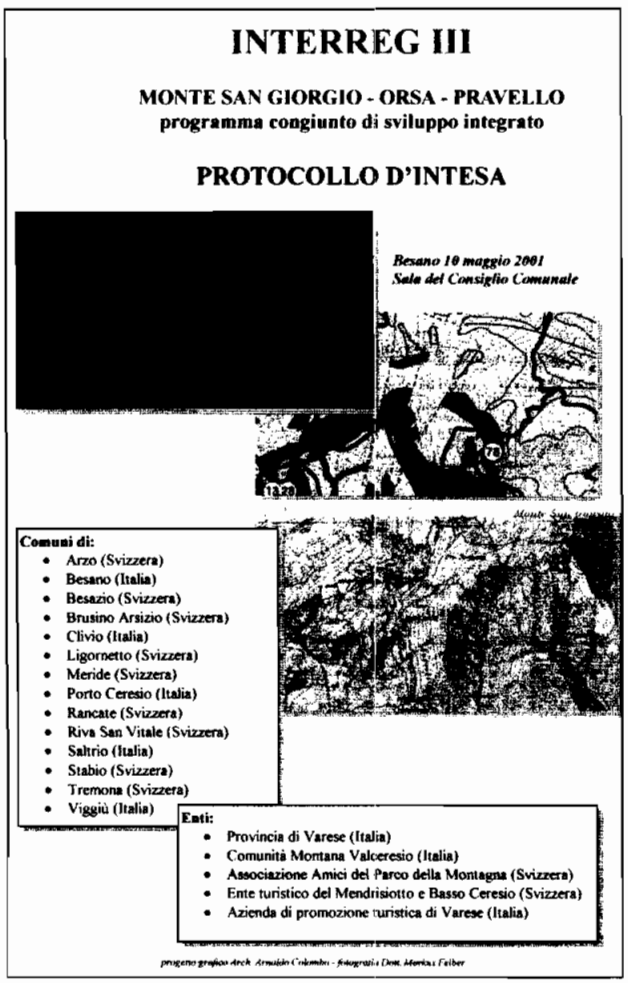



*Fig. 27: Draft agreement Interreg III*

An **educational trail** (Appendix **M**), illustrating the main geological and palae ontological features of the mountain, has been established in 1980 as a result of co-operation between the Institute of Palaeontology of the University of Zurich, the League for the Protection of Nature [Lega per la protezione della natura] (now Pro Natura) and the Mendrisiotto and Lower Ceresio Tourism Board. Information displays have been set up at intervals along the trail, presenting the area's physical phenomena, fauna and flora.

The following public and private-sector organisations are active locally:

- **The Meride Fossil Museum** (Appendix **N**). The museum was inaugurated in 1974 as a result of an initiative by the Palaeontological Institute and Museum of the University of Zurich and a number of local supporters, including the League for the Protection of Nature (now Pro Natura). Roughly fifty fossils, representing the main types found in the Middle Triassic formations of Monte San Giorgio, are

systematically displayed, with explanatory texts, in a single room. There is also a slide show illustrating the excavations, the main fossils found on Monte San Giorgio and their preparation. There are plans to enlarge and renovate this small museum, which is destined to play the local management role in respect of the region's palaeontological heritage. The enlarged museum will be able to house a larger number of exhibits and cover other themes connected with the geology of the area, such as the mining activities of the last century. It will also benefit from modern audio-visual facilities. The Museum is currently managed by a joint scientific committee, appointed by the local authority. This committee publishes information and is responsible for planning the new facilities. It is intended that, in future, the Meride Fossil Museum be managed by a public body (involving local-authority, cantonal and scientific representatives and sponsors), possibly having Trust status.

*Fig. 28: Guide to the Monte San Giorgio nature trail*

- **The Associazione Amici del Parco della Montagna [Friends of the Mountain Park],** based at Arzo, was established in 1990 with the purpose of protecting and promoting the natural, landscape, environmental, cultural and historical heritage of the mountain areas of Monte San Giorgio and Poncione d'Arzo (known together as La Montagna). Membership is open to public and private bodies, as well as individuals. Aware that the development of Western civilisation has been based on the appropriation and speculative exploitation of natural resources, the Association is militant in support of the concept of *sustainable development*, starting with the realities of daily life. Working in harmony with other environmental groups, it

intervenes in processes which determine the fate of local territorial and environmental resources. The Association's aims are: 1) to work for the establishment of a Natural Park in the area defined by the Federal Inventory of Landscapes of National Importance; 2) to contribute to the balanced and co-ordinated integration of human settlement and activities (cultural landscape) with the natural features of the area (natural landscape); 3) to safeguard, protect and promote the natural, landscape, environmental, cultural and historical heritage of the area; 4) to encourage good management of the territory through study and research, and by raising the awareness of local people and organisations; and 5) to press for co-ordination in planning matters between the local authorities in the region, and between these authorities and their neighbours in both Switzerland and Italy. The Association organises lectures, excursions, meetings, debates and study groups to deepen people's knowledge of the area and stimulate new ideas for environmentally friendly management. It proposes ways of achieving a balanced and harmonious relationship between humans and their natural environment. It is locally active in putting forward its own independent initiatives and adopting positions with respect to political and economic decisions affecting the territory.

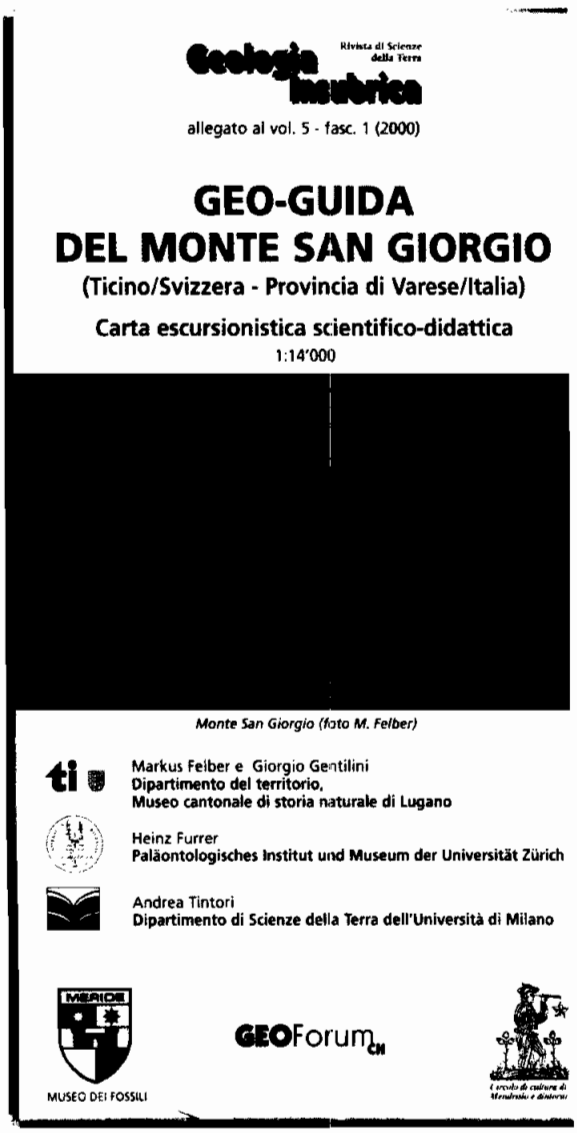

Geologia Insubrica
Rivista di Scienze della Terra
allegato al vol. 5 - fasc. 1 (2000)
GEO-GUIDA
DEL MONTE SAN GIORGIO
(Ticino/Svizzera - Provincia di Varese/Italia)
Carta escursionistica scientifico-didattica
1:14'000
Monte San Giorgio (foto M. Felber)
Markus Felber e Giorgio Gentilini
Dipartimento del territorio,
Museo cantonale di storia naturale di Lugano
Heinz Furrer
Paläontologisches Institut und Museum der Universität Zürich
Andrea Tintori
Dipartimento di Scienze della Terra dell'Università di Milano
MUSEO DEI FOSSILI
GEOForum CH

*Fig. 39: GEO-GUIDE to Monte San Giorgio*

The **GEO-GUIDE to Monte San Giorgio** (Appendix **L**), the first of its kind in Switzerland, is a collaborative venture between the local authorities and organisations active in the area. The publication, of which 6,000 copies were printed, is helping to improve people's knowledge of the palaeontological heritage of Monte San Giorgio, and also of the geological setting and the mining activities, techniques and traditions associated with quarrying. The Geo-Guide should provide a stimulus for other local initiatives: improving the network of nature trails for educational purposes, promoting industrial archaeology, opening the main palaeontological sites to the general public, publishing educational works, etc. (see also the section on cross-border initiatives between the nine local authorities in the Swiss area of Monte San Giorgio and the five on the Italian side).

To provide the necessary technical and political support for the many on-going and planned initiatives, the Committee of the Meride Fossil Museum, in consultation with the municipal authorities, has set up a **support committee**, made up of representatives of the academic, political and cultural worlds with an interest in the natural heritage of Monte San Giorgio.